MISSOURI

AGRICULTURAL COLLEGE EXPERIMENT STATION

BULLETIN No. 11.

TEXAS FEVER,

Investigations between September 1888 and March 1889,

—BY—

PAUL PAQUIN.

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ERRATA.

Cover Page, instead of "investigations between 1888 and 1889" it should read between 1888 and 1890.

Page 27, first line, read November 1889 instead of 1890.

Page 29, fifth line, first paragraph, instead of "65 head of BLACK CATTLE," read 65 head of short horns.

Page 48, TABLE of inoculation of PAGES 50 and 51 should follow, and be read immediately after page 48.

Page 49. The table of "inoculation of OTHER animals than cattle," should come under the headlines of pages 50 and 51 instead of page 49. In other words the table of page 49 should be on pages 50 and 51, and the table of 50 and 51 should be on page 49,

TEXAS FEVER.

(Southern Cattle Fever, etc.)

INTRODUCTION.

No disease of cattle causes anything like as great a loss yearly to the people of the West and South as does this misnamed and fatal one, and not unfrequently it is carried even to the East. The northern farmer and stockman is almost absolutely deprived of the grand market that the infectious Southern States offer to them. Fifty to seventy per cent. of the northern cattle shipped south of the fever line including, of course, the importations of improved stock to raise the quality of the Southerner's herd, die from Texas fever. On the other hand the northern pastures that offer such rich source of profit to cattle feeders, are forbidden to the southern cattle, both by the contagion which they carry and by laws passed in consequence. If there be transgression, several usually pay dearly for the sin by the death of cattle and lawsuits. Thus, the damages caused to all these States that must profit enormously by inter-state cattle commerce, if it were not for that incontrollable malady, are incalculable. Counting with those difficulties the legal and moral restrictions on commerce by quarantine regulations, the situation is indeed gloomy.

Since 1885 I have given some thought to Texas fever. I began noting down my observations in that year, and in 1886 and 1887, I made microscopical researches and observed a micro-organism in connection with diseased organs and blood. These studies, however, were meagre and unsatisfactory—being made while travelling constantly as State Veterinarian for Missouri.

I procured much literature on the subject, including the reports of the Bureau of Animal Industry. All seemed confusion. Investigators were apparently far apart. Rauch in 1867, The Metropolitan Board of Health about the same period, the Bureau of Animal Industry 1869-70 and later, Gamgee in 1871, Detmers in 1884 and at other times, Billings 1887, presented the case from a variety of standpoints. With this conflict of ideas at hand I was called upon to make experimental investigations.

Putting aside with due respect, all publications, including Billings which was the latest, we laid our plans and set to work seriously and independently in September 1888. By order of Gov. Morehouse and under instructions from the Executive Board of Curators and the Dean of the Missouri Agricultural College I proceeded South. In Texas I was cheerfully assisted by Gov. Ross, through whose kindness a meeting with the officers of the Agricultural College of that state was effected.

There, arrangements were made with the Agricultural College Experiment Station for intershipments of experiment stock and co-operation in investigation,—the direction of the studies to be with me. Later like arrangements were made with a similar institution at Fayetteville, Arkansas. At about the same time I also arranged for researches in the Indian Territory, and then to experiment at some public stock yards in Missouri. Stock pens were also constructed for southern cattle and others a few miles from my home in Columbia.

As for the bacteriological work, all was ready for it at the laboratory in my charge as State Veterinarian.

Since the institution of these investigations I have purposely omitted to follow any of my learned predecessors in this domain of research. During my investigations I never consulted any work about Texas fever. Consequently the work was absolutely uninfluenced from its origin and has been free from all bias.

Much credit is due to Dr. M. Francis, of the Texas Agricultural Experiment Station, and to Dr. R. R.

Dinwiddie, of the Arkansas Agricultural Experiment Station, for their valuable help and contributions in our joint labors and in carrying out instructions skillfully and scientifically. Dr. Francis particularly, has rendered valuable services in his extensive excursions throughout Texas to gather material for study and experiment.

In the laboratory at Columbia I was aided first, when the investigations were most obscure, by Dr. Jno. W. Connoway, an accurate Veterinarian, now practicing at Columbia, Mo. His skill and prudence contributed much to the solution of many intricate problems that confronted us on the outset. He was succeeded by Dr, B. R. Harmon and Mr. Paul Evans. The former assisted only pending his admittance to the College of Physicians and Surgeons at St. Louis. Mr. Paul Evans is my present assistant; he has, since his appointment, patiently performed a large share of the tedious detail laboratory work and has shown himself a careful and ingenious investigator.

It is fitting and just also, that I here acknowledge the assistance of the Kansas City Stock Yards which furnished $100.00 and the use of stock pens, and of the National Stock Yards, East St. Louis, Ill., which contributed the same amount of money. By their help we were enabled to build special experiment pens for which purpose we had no funds.

We are grateful to the M. K. & T. Railway for considerable reduction in freight on experiment cattle shipped to and from the South, and for their support in our enterprise. We hope that the results of our experiments will soon be such as to be beneficially put in practice by all who have so generously aided in the work.

I will now proceed to report the investigations and experiments as made, and as I write more particularly for the masses I shall endeavor to avoid technical terms as much as possible. I will endeavor to write for the scientist later.

The *truth* in the matter, is all that we were searching for, and here are the facts as we found them to the date of this writing. Later, if we find any error, we shall make correction.

We may come in conflict with popular ideas or even scientific theories and beliefs, but we must conscientiously give the results irrespective of all dissenting views, and we do so with due regards for, and conscious of the abilities, energies and reputation of the scientists who have so earnestly and faithfully preceded us in investigating Texas fever.

In other words here is the exposition of long, conscientious, careful, tedious and difficult investigations and experiments. I very respectfully submit the whole to the careful consideration of my fellow men, hoping that they may see facts that will contribute to their welfare. Our task is not completed, we have much to do yet; but we will feel very happy indeed if good comes to the people through our humble efforts to this date.

OBJECTS OF THE INVESTIGATION.

Before setting to work, we formulated the following propositions:

1. Determine the places in the soils, waters, grasses, etc., of Texas and other places in which Texas fever virus exists.

2. Determine the part or parts in the body of southern cattle, or their products, where Texas fever virus may be found (and from whence it may be transferred).

3. Determine the accessory sources (of transmission of virus) such as hay, ticks, hoofs, foods, etc.

4. Determine the period of incubation of the disease in northern cattle.

5. Determine the duration of infection in southern stock (i. e. how long they are capable of conveying Texas fever).

6. Determine the best and cheapest modes of disinfection of cars, yards, etc.

7. Test means to disinfect southern cattle alive and render them harmless before shipping north.

8. Experiment with a view to render northern cattle safe against Texas fever before shipping them south—that is, to make them proof against Texas fever by vaccination or otherwise.

9. Determine whether horses or other animals ever take truly, or bring us Texas fever as seems to have occurred.

10. Determine how long on pastures or other places in the north, the Texas fever germs exist in dangerous nature.

11. Determine if under any condition northern cattle can cause infection of other northern stock.

12. Determine whether calves born south become proof against Texas fever by natural inoculation from the mother before birth, or afterwards on the soils, or if by both processes.

ARTICLE I.

PRELIMINARY SERIES OF INVESTIGATION.

PART I.

GATHERING OF SPECIMENS.

This work, begun in October 1888, had a twofold object. Besides being undertaken with a view to solve questions 1, 2 and 3 mentioned in the preceding page it was also meant as a preliminary survey of the grounds to be more thoroughly searched afterwards. During my trip in Texas and the Indian Territory, September, 1888, I collected soils, manures, urines, ticks, livers, spleens, kidneys, blood, bile, specimens from unborn calves, fodders and waters from various sources on infectious grounds. Later Dr. M. Francis of the Agricultural College and Experiment Station of Texas, furnished me with a greater number of articles of the same order, and later still Dr. Dinwiddie of Arkansas gathered several. As a result, between

September, 1888, and the spring of 1889—i. e. during the cool and cold seasons we investigated at the laboratory 148 different specimens from the south,—over 100 of which had been gathered under written instructions, by Dr. Francis in counties of Texas, north, south, east and west.* Such specimens as liver, kidney, spleen, etc., were taken fresh immediately after death of the animals at slaughter houses, then wrapped in cloths previously soaked in either a strong solution of bichloride of mercury (corrosive sublimate), or carbolic acid, then they were immersed in pure glycerine in fruit jars and sealed. They all were preserved absolutely free from the usual results of contamination by air germs. The specimens of blood, bile and urine were nearly all sealed in sterilized glass tubes (pipettes) without being exposed to the air. Really all the foregoing substances therefore, were preserved and studied containing the same things as before the death of the animals that furnished them.

PART II.

STUDIES OF THE SPECIMENS.

Our endeavors were first directed towards the discovery in the foregoing specimens. of a virus capable of producing Texas fever. With that end in view many difficult problems presented themselves. It was during the cold season when the disease is induced with difficulty, and at a period when we knew of no other animal susceptible to the fever in question than cattle, which could scarcely be bought for less than $20 per head in average. Our limited means precluded the use of many such comparatively high priced experiment subjects. Consequently we had to go very slow.

*Dr. Dinwiddie's specimens were not sent that season.

First Investigations: Blood, Urine, Bile, Liver, Spleen and Kidney from Healthy Southern Cattle and from Unborn Calves, (fœtus.)

Thirty-three different specimens from *twenty* different southern cattle of several counties of Texas, and the Indian Territory were analyzed. In all of them without exception we found after a long and tedious search, germs that could be seen plainly and stained fairly well. Unstained in the tissues of the liver, spleen, kidneys, glands, the germs appeared as bright or bronze colored corpuscles, of irregular shapes, apparently grouped in and out of the cells of the organs, and disseminated in the spaces and tissues. Some of these bodies appeared almost spherical, others like bright specks, and still others as ovoid bodies or short oval rods of various dimensions.

In the blood and bile the germs were found frequently in a motile condition. They would roll on themselves, bend two and fro, move from place to place taking a variety of shapes which gave them a resemblance with some of the corpuscles found in the liver, etc. The germs could be stained in the blood and tissues, but only with difficulty in the bile. The forms in the blood were small and like the finer organisms in the tissues. The blood elements were impaired. In the bile, the germs were often in the shape of rods of considerable length. It contained, also, as the kidneys and urine fine, bright bodies, occasionally double as diplococci.

Our first attempts to cultivate these germs artificially were not satisfactory, but still we did reproduce some forms.

Our next step was to investigate the soils, manures, waters, fodders, etc., etc., to see if the same species of germs could be found. We discovered similar forms

mingled with numerous others in every specimen with the exception of dry hay, subsoil, spring water, well water and one specimen of surface soil. The manures were particularly prolific. We made cultures and succeeded with difficulty and not very satisfactorily, to produce germs similar in appearance and in mode of growth to those grown from liver, spleen, kidney and bile. Inoculation of white mice with these cultures in state of purity caused death occasionally, but only when a large quantity was used. The same germs were found in the liver, spleen, etc., of the little animals that had thus perished.

With these cultures, however, we could not kill cattle with typical symptoms of Texas fever, although we did produce fever as high as 104 ° and 105° F. in some of them.*

DEDUCTION.

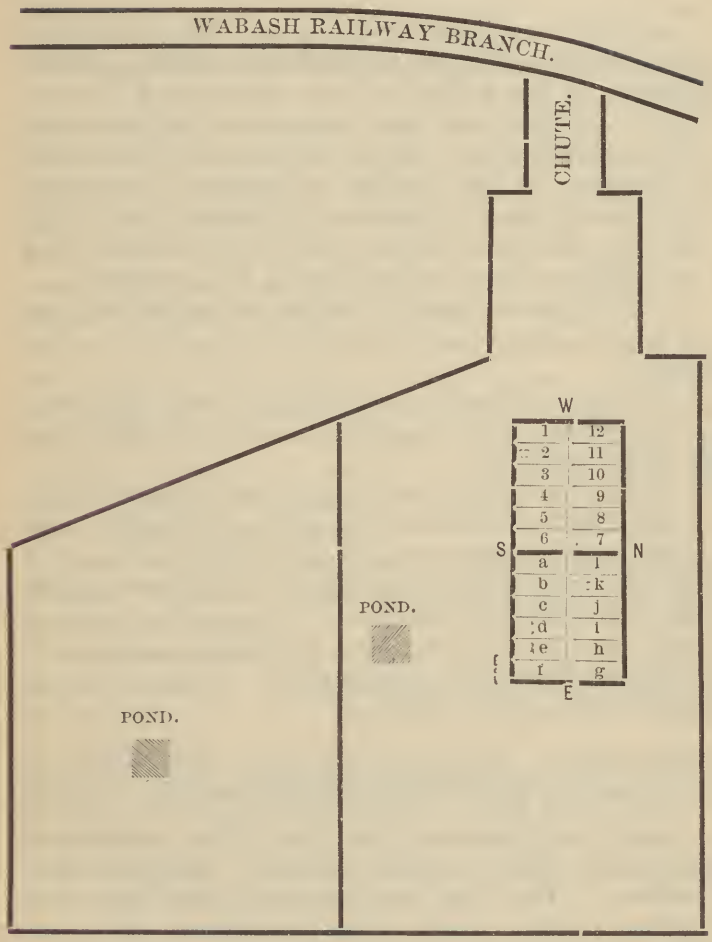
It will be seen by these preliminary researches, as imperfect as they are, that two important probabilities were established. First, that certain microscopic beings —germs possibly identical in most of the cases, were found in the normal liquids and *tissues* of infectious southern cattle that *always appear healthy*, and even in the *young before birth* (one was not older than four months after conception), as well as in the manures, surface soils and waters, etc., of grounds where the fever originates. Second, that this germ was absent in dry fodder, in well water, spring water, the subsoil, (even the deep layer of sod being free).

True, we were groping somewhat in the dark, and under disadvantages that made progress exceedingly slow, tiresome, and even somewhat doubtful to us, but it pointed to a possible clue. It furnished something like a tangible basis for further operations.

Question 1, 2 and 3 of our objective task being partly answered, we could take up the remaining nine—i. e. 4, 5, 6, 7, 8, 9, 10, 11, 12, with more hope. (See page 6.)

*The normal temperature of cattle is about 101 deg. F.

EXPERIMENTAL GROUNDS.



Pens 1, 2, 3 (and even 4 and 5) and 10, 11, 12 were more shaded than the rest. Pen 1 particularly, was well protected from the sun almost constantly.

ARTICLE II.

FIRST FIELD AND LABORATORY EXPERIMENTS WITH SOUTHERN CATTLE AT HAND.

A thirty acre pasture was secured on the Wabash railroad between Centralia and Hallsville, in Boone county, Missouri. It was divided into two portions and in one of them twenty-four pens were constructed with alley and chute leading directly to the railroad track, where, through the kindness of the Wabash management, experiment cattle were afterwards loaded and unloaded at will. The pens were divided in two sets—one dozen numbered from 1 to 12 and one dozen lettered from A to L, inclusive.

The diagram on page 11 represents the grounds and the pens numbered and lettered as referred to in this writing.

Mr. Monroe Hampton, a practical farmer and veterinary medical student, was superintendent and discharged his duties faithfully.

The strong board fences forming the enclosures were six feet high, and so closely framed that the cattle could not eat through although they could smell and even lick each other between the upper boards. The bottom boards came close enough to the ground to prevent eating underneath. The cattle were fed on the ground and watered in troughs purposely constructed. Their food was hauled to them from a distance.

Experiments A: Tests of the virulence of Texas cattle, and exposure of unprotected northern natives.

June 20th, received from the Texas Agricultural Experiment Station 18 head of cattle supposed to be infectious. They had been shipped June 15th from Uvaldo, Uvaldo county, Texas, in a Street stable car. Before loading, the floor was covered three inches thick with sawdust and sand soaked with fifty gallons of water containing five pounds of corrosive sublimate, (a quantity much larger than necessary), and a board was placed

inside all around the car to prevent any droppings on the track from the floor.

After unloading the cattle at the experiment pens, the car was hauled to Hallsville and then to Columbia. Northern cattle *had access* to it and to the manure it contained, *not a case* of Texas fever occurred thereby. The cleanings of this car were also purposely tested on native Missouri cattle and failed to produce the disease. Those 18 head of Texas cattle were distributed as follows: pen 1, seven head; pen 2, eleven head. Three Missouri natives were put at once (June 20) with the Texans in pen 1. The eleven subjects of pen 2 were changed every second day from pen to pen until they reached pen 9 inclusive, then every day until pen 12 inclusive, which they left July 9th, making in all 19 days in pens, and with the 5 days of travel making twenty-four days since they left Texas soil. *June* 21*st*, two native northern cattle were put in pen 2. *July* 12*th*, we began to test the virulence of pens 3 to 8 inclusive where Texas cattle had been, by putting one head of northern cattle in each. The results were as follows:

July 30*th*, cow in pen 8 died of Texas fever, exposed 17 days. Virus or germs had been deposited 30 days before by the Texans.

August 5*th*, bull in pen 5 seriously ill with the disease, exposed 23 days. The germs had been on the grounds 42 days at most.

August 14*th*, cow in pen 1 died of Texas fever, exposed 55 days. The germs had been deposited by Texas cattle June 20th, or 55 days before. (This pen in shade.)

August 15*th*, heifer in pen 7 died of same disease, exposed 34 days. Germs on the grounds since June 28th, or 49 days. (Pen not shaded.)

August 16*th*, heifer in pen 6 died, exposed 35 days. The germs were in the pen since June 26th, or 51 days.

The exposed subjects in pens 2, 3 and 4 showed very feeble signs of illness. Nothing to be noticed by any one but the experienced observer. (Pen shaded part of day.)

We had not enough cattle to test the virulence of pens 9, 10, 11, and 12, but the Texas stock after leaving pen 8, i. e. the 24th day after shipment from the south, seemed no longer infectious, as we mingled them with native stock in the pasture and no disease occurred thereby. I do not consider the test sufficient however on this particular point.

June 21*st*, manure fresh from Texas cattle was deposited on the grass of pen G, and some was forwarded to the laboratory for analysis and tests.

June 22*nd*, 24th and 28th urine fresh and pure from Texas cattle was spread over the grass in pen F, and some of the same specimens were studied at the laboratory.

Neither of these pens were at any time contaminated from any other source.

August 6*th*, a native steer was placed in each pen.

August 27*th*, or twenty-one days after exposure the steer in pen F died of Texas fever, having contracted it from the urine deposited on the grounds 66, 64 and 60 days previously.

The steer in pen G where the manure was placed, showed so faint signs of the malady that only an experienced Veterinarian could have observed anything unhealthy.

*Experiment A*1*: First exposure of inoculated (or vaccinated) northern stock.**

August 17*th and* 27th. After some of the deaths above recorded, and after pens 1 to 8 inclusive had been proven infectious, the disease and deaths recorded, they were thrown open together and in them were placed ten more head of Missouri cattle; six of which had been purposely inoculated with view to protect them; and four were not inoculated. The six inoculated ALL RESISTED the fever, whilst of the four not inoculated TWO DIED of Texas fever, one was seriously ill and recovered, and the other had no

*Inoculation and vaccination are used here in the sense of protective inoculation with modified germs.

signs of serious sickness. These inoculations were made with weakened virus. More of this in the article on the subject of inoculation.

Experiments A2: Analysis of specimens from some of the above mentioned Texas cattle and from natives that contracted the fever.

Fifteen fresh specimens of manure, urine, blood, bile, liver, spleens and kidneys of different apparently healthy Texas cattle, were analyzed microscopically, and in all instances germs similar to those already described were found. The liver and bile in particular contained a great many.

Twenty-six of the same kinds of specimens from all the Missouri cattle that died from Texas fever, or that were killed while suffering from it, also presented *always* the same germs but in greater numbers. Great care was taken that the specimens in every case were procured right after death by fever, or right after killing the patient so affected. A special Article on the germ of Texas fever will be found further.

Inoculations of Missouri cattle with *strong* virus from infected organs of both *Texans* and *natives* produced Texas fever. That also will be better explained further on.

Experiments B: Tests of Arkansas cattle.

June 28th 1889. Dr. R. R. Dinwiddie (Veterinarian of the Experiment Station of Arkansas) shipped us from Helena, that State, in a car *prepared as for* the Texas shipment, 25 head of cattle supposed to be capable of conveying Texas fever. They arrived at our pens July 1st. The cattle had been marked and divided into several lots, and part of them had been dosed with antiseptic drugs, with a view to destroy the activity of the germs in the animals, and render them powerless to cause the disease on their arrival here. Unfortunately the man who accompanied the stock failed to do his duty. On

his way here he mingled the treated and untreated cattle together in the previously separated car, and then he left them by themselves during a large portion of the journey. The result was, the stock could not be identified positively by the torn tags or for the want of marks; consequently the object desired in so treating the cattle antiseptically, before shipment from Arkansas, could not be intelligently sought. We therefore repeated in different pens the experiments made with the Texas cattle.

In pen A, five cattle were placed; in pen B, five; in pen C, four; and in pens J, K, L, opening in one another, eleven.

Three of these Arkansas cattle, one in pen A and two in pens J, K, and L, were sickly when they arrived and soon succumbed.

In *two* of these there were *marked lesions* of Texas fever, and its specific germs were found in abundance. The other had a severe lung congestion with mild lesions of Texas fever. These deaths are attributed to a combination of causes, chief among which were two days neglect in feeding and watering by the negro who should have closely attended to the stock as ordered by Dr. Dinwiddie. Right after the severe treatment that these animals had undergone, their bodies being impregnated with Texas fever germs, the best hygienic condition possible was necessary.

July 30th, all of those Arkansas cattle were turned out of the pens. The same day five *inoculated* Missouri natives and two *not inoculated* were put in pens J, K, and L. The inoculations had been made with virus of a nature which was doubtful at the time of operation.

Aug. 8th, one native cow was turned into pen C; not inoculated.

Aug. 11th, one native heifer was turned into pen B; not inoculated.

Aug. 20th, one native cow into pen E; not inoculated.

The results were as follows:

Aug. 20th, in pens J, K, L, *one vaccinated* animal and next day *two unvaccinated* presented symptoms of Texas fever.

Aug. 25th, heifer in pen A died of Texas fever; not inoculated.

Aug. 27th, one cow in pen C fatally ill from Texas fever and killed purposely; not inoculated.

Same date one of the *unvaccinated* heifers in pens J, K, L, died from Texas fever.

Thus of the five vaccinated or inoculated, one was sick but not one died; of the five unvaccinated exposed in different pens three died of Texas fever.

Experiments B1: Analysis of specimens of Arkansas and diseased native Missourians.

Just as for Texas stock, specimens of various kinds were carefully investigated. Seventeen large specimens of manure, urine, blood, bile, liver, spleen from four different Arkansas cattle, and fifteen similar ones from natives that died from or were killed on account of Texas fever were collected fresh and subjected to searching microscopical examinations and bacteriological studies. In all of them the germs found in *Texas cattle* or diseased *natives* as stated in experiments A etc., were noticed.

Experiments C: Tests with the second lot of Texas cattle.

These consisted of 18 old cows shipped by Dr. Francis from the ranch of Col. Fulton near Corpus Christi, Aug. 6th or 7th.

They arrived at our pens Aug. 13th. The car had been previously prepared to prevent infectious droppings on the track as for the other shipments.

This lot was intended for the purpose of testing means to disinfect southern cattle alive and render them harmless to northern cattle. Some of them were to be untreated to serve as witness cases. Unfortunately, Dr. Francis failed to secure the consent of the owner to this arrangement, and the cattle were shipped to us to be tested as to

their individual virulence—the owner claiming that the cattle of his ranch never convey Texas fever. Our investigations not being carried on for any one ranch however, this testing of one exclusive herd of cattle irrespective of a plan prearranged on an intelligent basis, and with respect to our financial condition, and the welfare of the country at large was not desirable. However, we did the best we could under the circumstances. The Fulton cattle were all placed in pens I and H that never had been used for any purpose.

Sept. 9th, one yearling steer and one yearling heifer, natives, were put in the above pens. We had been unable to find before this date any stock at sufficiently low price for our extremly limited funds.

Oct. 19th, these two native cattle were turned out, no signs of fever having been detected by the superintendent. The thermometer was not used.

Experiments C1: Analysis of specimens from the Fulton cattle.

Samples of urine, manure, bile, blood, liver and spleen demonstrated the germs in a comparatively scarce quantity. Inoculations of a native heifer with small quantities of virus from these animals produced only a slight fever. By inoculation of a large quantity of liver pulp we did succeed in producing a good case of Texas fever in a native. These cattle seemed less virulent than others that we had. I am informed that the Fulton ranch is supplied with well and sulphur water.

This suggests a valuable proposition perhaps. Is it not possible that the peculiar water of the Fulton ranch is antagonistic to the life of the germ of Texas fever and thereby modifies its virulence? We know the antiseptic properties of sulphur for instance, and this is one of the very agents that we had instructed Dr. Francis to use to disinfect southern cattle alive before shipping them north.

DEDUCTIONS FROM THE EXPERIMENTS OF ART. II.

1st. That some of the germs found in our preliminary investigations of southern soils, waters, manures, urine, bile, liver, etc., etc., and those found in the bodies of *southern cattle* subsequently shipped to us, and found in *cases* of *Texas fever* in *northern cattle* are identical.

2nd. That the germs of Texas fever are to be found in *all southern cattle* coming from infectious grounds, and not only in their manure, but in their blood, livers, spleen, kidneys, urine, etc., notwithstanding that they apparently remain healthy. The same is the case even with *unborn calves* which are therefore naturally *inoculated in the mothers' womb.*

3rd. That the average period of exposure before the Texas fever appears north, in cattle exposed to the freshly deposited germs brought by southern stock is about thirty days; but this may vary much according to the sun heat and warm weather which is a favorable condition, and cool or cold which is unfavorable. The cattle in pens 1, 2, 3, 4, which were more shaded than the remainder resisted longer and better.

4th. That the germs in fresh excretions of southern stock remain apparently harmless between 30 and 50 days, and in a cool shady place may remain thus still longer.

5th. That cattle exposed to either *manure* or *urine* from southern stock may contract Texas fever, and that inoculation from pulp of liver or spleen of such subjects may produce it.

6th. That the germs must be taken into the body by the mouth or by inoculation, and that the disease is not conveyed by the breath of infected or infectious individuals.

7th. That protective inoculation may render the system of northern cattle capable to better resist the action of the Texas fever germ.

8th. That sulphurated water is perhaps inimical to the life of the germ and favorable to its modification and death.

ARTICLE III.

SPECIAL EXPERIMENTS TO TEST PROTECTIVE INOCULATION.

Note: Having discovered early in our experiments that southern calves really have the germs of Texas fever in their system before birth, I became convinced that that was the first reason of the immunity of southern stock against this affection. The young are actually inoculated, or vaccinated to use a more familiar though not so accurate term, in their mothers' wombs, and when dropped on the infectious southern soil they are prepared to meet the virus that it contains just as well as a child vaccinated against small pox can be safely exposed to that disease. The question that impressed me then was this: Why cannot the northern cattle be artificially inoculated with the germs of Texas fever before exposing them south, or on any infectious ground, on the same basis that the southern calves receive the germs from their mothers? I believed it possible; and we began experiments to that end. We soon found, however, that the proposition was not as simple as it appeared; obscure problems and discouraging failures met our efforts every hour of the day, and it required constant harassing microscopic researches, and tiresome operations to keep at all in anything like a reasonable route. Inoculation after inoculation proved futile. We could scarcely detect anything like Texas fever symptoms in our first attempts to transmit it. Little by little however, the darkness disappeared, the way became clearer, and at last we had in our possession and partly under our control, the germ of the deadly plague; and we could cause this malady almost at will in a more or less virulent form. And at this writing we can cultivate the germs with comparative facility outside of the animal body, and then reproduce them in cattle by inoculation with such artificial cultures. Thus after testing many kinds of virus and cultures from many sources, some of doubtful and others undoubted activity

and purity; after inoculating by several methods, once, twice, thrice or oftener in each case, with strong doses all at once, or several weak and strong at intervals; after trying gradual inoculation beginning with a mild virus and ending with a powerful one; after sacrificing many animals here and in the South we feel glad, for we have we think partly conquered, and the people, our employers may reap the great benefits that are sure to come if our future work gives the results promised.*

PART I.

PROTECTIVE INOCULATION OF CATTLE SHIPPED TO TEXAS AND ARKANSAS.†

June 24th, six inoculated and six not inoculated head of cattle were shipped to College Station, Brazos Co., Texas, where they were put on pasture and attended to by Dr. Francis. The three kinds of virus used were not known to be positively reliable in any sense. Our experiments had not as yet given us a positive clue to its powers and effects. The elucidation of this double problem was one of the objects of this shipment.

Sept. 11th, shipped to the same place fourteen head of cattle, i. e. ten inoculated and four not inoculated. They were also put on pasture. The atmospheric temperature was exceedingly warm. §

The results obtained, as given by report of Dr. Francis, dated December 19, 1889, were as follows:

First shipment. Of the six not vaccinated five died of Texas fever within three weeks and the other was ill and recovered; of the six inoculated, four died. Now these inoculations had been practiced once before leaving Columbia, and once in Texas, the virus being of a very *doubtful* nature as before mentioned. Total per cent. of

*I give in this bulletin our failures as well as successes.

†Inoculation and vaccination here mean the same.

§The inoculated cattle of these shipments were Missouri natives

death of vaccinated stock 66 2-3, the non-vaccinated stock 83.3 per cent.

Second shipment. Of ten vaccinated two died of Texas fever; of the four not vaccinated three died and the other recovered after severe illness. Total death rate among the inoculated or vaccinated stock 20 per cent., among stock not so protected 75 per cent.

The origin of the virus used for inoculation was manure, liver, blood, etc., and had been cultivated or prepared artificially.

It will be seen that the last shipment was more successful than the first although far from satisfactory. It remains to be said that the stock thus treated and exposed that did resist Texas fever, did not do as well as stock of southern origin kept on the same grounds. The subjects remained poor for a while.

July 5th, four inoculated cattle and four not inoculated were sent from Columbia to Helena, Arkansas, and there exposed on the grounds under the care of Dr. Dinwiddie.

Aug. 9th, eleven head, six inoculated and four not inoculated were shipped to the same place. Four different kinds of virus of unknown strength and power had been used as a logical deduction of laboratory studies, with a view to test the chances of finding a protective kind.

The result of the two experiments was that *one died of Texas fever* on the *cars*, *the effect of inoculation*; twelve succumbed on the grounds, (possibly two of these died of Anthrax) and six are now living. From the latest report of Dr. Dinwiddie I infer that the latter *were all* inoculated stock. However that may be, the results in a general way could not be considered encouraging. But when it is explained that nearly all the inoculated stock that survived these four shipments to Texas and Arkansas had been treated with virus of *similar origin and nature*, it gives hope that some good will come of this particular

kind. Dr. Dinwiddie's report of much faithful work, shows 100 per cent. of death of non-vaccinated, 75 per cent. vaccinated.

PART II.

INOCULATION IN HOUSTON, TEXAS CO., MO., AT THE KANSAS CITY STOCK YARDS, AND AT OUR EXPERIMENT PENS.

July 19th, an outbreak of Texas fever of extensive character was reported at Houston, Texas Co., Mo. Dr. B. R. Harmon, then of the State Veterinarian's laboratory was deputized to attend to the matter. He remained ten days on the grounds and found that several car loads of southern cattle, had been brought in the county April and July, and scattered over the unfenced lands to roam at large. Some fourteen head of the natives among them had died and several were sick with Texas fever. Dr. Harmon practiced inoculation with an artificial preparation of the germs of Texas fever on 31 head of cattle. They were left exposed with the southern cattle on the infected grounds. All remained healthy, but it was reported that several of the unprotected cattle left with them, afterwards contracted the malady and some died. This was only an incidental experiment during our regular investigations and is not of itself sufficient evidence.

At the Kansas City Stock Yards.—The work here was conducted by Dr. H. B. Adair, Deputy State Veterinarian, a skillful surgeon, and witnessed by P. D. Etue, Esq., Editor of the Kansas City Live Stock Indicator, who manifested a great deal of interest in the undertaking and sacrificed much time to it. Dr. J. A. Walrath, of the Bureau of Animal Industry, was present also on several occasions.

August 10th, six native heifers were placed in lot 13, block 20 which was free from contagion. They had never

been exposed to Texas fever and were in good health. Temperature of the six averaged 101 1-5 deg. F. before inoculation. Heifers Nos. 1, 2 and 3, were inoculated with an artificial culture of Texas fever germs furnished by me.

Aug. 14th, heifers Nos. 4, 5 and 6, were inoculated as directed by me with spleen and liver pulp taken from a case of Texas fever soon after death. This virus, unfortunately contained some septic germs and caused some little trouble.

During the next six days after inoculation the temperature of the first lot inoculated rose to an average of 102 4-5 deg. and that of the second lot rose to an average of 104.

Aug. 17th, Nos. 1, 2 and 3, were reinoculated with the same kind of cultivated germs but of greater virulence. During the five days following this inoculation the temperature rose to an average of 103 2-5 deg. Thus the first three were inoculated twice, and the second three only once.

Aug. 22nd, both lots were examined and the temperature for each was as follows: *First lot* (inoculated twice), No. 1, 102 2-5° F; No. 2, 103 2-5; No. 3, 103 1-5; *second lot* (inoculated once), No. 4, 105 1-5; No. 5, 103; No. 6, 105 2-5; Nos. 4 and 5 appeared sick.

Aug. 24th, the temperature had abated in all six to an average of 103 deg. F. The inoculation with spleen and liver pulp had produced swellings and slight abscesses, at the points of inoculation—the brisket. This date all the *vaccinated animals*, together with three others, *Nos. 7, 8 and 9, not vaccinated*, were driven across the stock yards bridge to the Kansas side, and there placed successively in lots 12, 6 and 5, block 32, occupied sometime previously by southern cattle that had proven their power of conveying Texas fever.

The final results of this experiment are given by Dr. Adair as follows: "Case No. 3, *inoculated*, died of Texas fever; case No. 4 died of septicemia induced by the *inoculation*. Neither the symptoms nor the lesions found in post-mortem examination indicated Texas fever. (Microscopic investigation verified this diagnosis.) The remaining four, all vaccinated, remained healthy. No. 7 not vaccinated died early of Texas fever. Nos. 8 and 9 also unprotected, both contracted it severely but finally recovered. Thus of the *six vaccinated*, *only one* contracted Texas fever, whilst the *three unvaccinated subjects all* became affected, and one died. During the fifty-five days of this test, the weather was very warm. The cattle were kept in open pens exposed to the sun's rays. Their solid food consisted of hay only, and sometimes it was not good; consequently all of them became thin and the trial was a most severe one."

At our experiment pens: As mentioned already, inoculated and unvaccinated cattle were put in infectious pens 1 to 8 inclusive, Aug. 17th and 27th.

THE FOLLOWING TABULATION SHOWS THE MOST IMPORTANT POINTS OF THESE EXPERIMENTS AT A GLANCE.

Case.	Inoculated or not and date of inoculation.....	Origin and activity of virus used for inoculation.....	Average temperature of animals from 1st to 5th day.	Lowest and highest temperature of the cattle from the 10th to the 20th day.....	Results after twenty days of exposure and later....
A	No.		101 3-5 F.	102 to 103 F.	Died of Texas fever.
B	No.		101	102 3-5—103 3-5	Very sick but recovered.
C	No.		101	101—102	Apparently well always.
D	No.		102	102—104	Died of Texas Fever.
E	Yes. July 20	Spleen—weak.	103	103—104 1-2	Fever diminished.
F	Yes. July 20	Spleen—stronger.	104	103 2-5—103	Not sick to show symp.
G	Yes. July 22	Spleen—weak.	102	104—106	Fever declined.
H	Yes. July 26	Artificial cult.—strong.	104 1-2	103—102 3-5	Not sick apparently.
I	Yes. July 26	Artificial cult.—stronger.	105	104—103	Fever from inoculation, not sick from exposure.
J	Yes. July 26	Liver—very strong.	105	105—104 3-5	Sick from inoculation, not from exposure.

Thus of the *four not inoculated* before exposure, *two* died of Texas fever, *one* was very *seriously* ill and the other remained apparently well. *Of the six inoculated none died,* two were not sick and the remainder sick mostly from inoculation as explained in the result column. The subject of protective inoculation will be especially treated further.

PART III.

INOCULATION OF CATTLE SHIPPED TO PRIVATE INDIVIDUALS IN THE INDIAN TERRITORY AND TEXAS.

In November 1890, after we had learned the lessons of the preceding experiments, an agreement was entered into between Dr. A. W. McAlester of Columbia, Mo., and the writer, to the effect that forty head of high grade or thoroughbred hereford, shorthorn and other cattle were purchased by the Doctor for his cousin, J. J. McAlester of McAlester Station, Indian Territory, and that we inoculated them, and shipped them to the latter place where they were scattered over infectious grounds on which the death rate by Texas fever had always been so severe, even during the greatest part or the whole of mild winters, that Mr. McAlester after repeated and fatal trials, had given up the importation of northern stock. The process of inoculation was gradual, giving twenty drops of virus to each head every third day until four inoculations had been practiced. Each successive virus was stronger than the preceding and the last was very virulent. The animals were shipped next day after the last inoculation, and were unloaded at McAlester Station, Dec. 1, 1889, about two days after shipping.

During the inoculation process, the temperature rose from the average normal of 101 2-5 Deg. F. to a fever averaging 103. When they reached the Territory this fever had declined some as proven by Dr. Grubbs who registered the temperature for Mr. McAlester. The results of this trial are given here in the language of the purchaser himself.

McAlester Station, Indian Ty., Jan. 25, 1890.

Dr. Paul Paquin, Columbia, Mo.

Dear Sir:—I am unusually busy but I send you a short memorandum.

Of the forty head bought and inoculated by you *only* one died of Texas fever some time since. A neighbor received from Missouri two cows and two yearlings not

vaccinated and placed them on practically the same ground at about the same time that mine were put on pasture and every one of his died of Texas fever.

I am of the opinion that this vaccination with the treatment that you prescribed will save nine-tenths of the cattle, particularly the young stock shipped to this climate. This has been an unusually warm winter. Most of the cattle are now scattered over the country and all doing very well but one and he is doing fairly.

SIGNED J. J. McALESTER.

March 12th, I received a verbal report from a Mr. Jackson from McAlester Station who had seen the stock recently. He reported them all doing well and only five or six, excepting the one that died, had ever shown any sign of indisposition.

The usual death rate of northern cattle in the Indian pastures where these were exposed has always averaged over fifty per cent, and continued its ravages in the winter, especially mild winters.

CATTLE SHIPPED TO THE KENNEDY RANCH, ALICE, TEXAS.

Dec. 14th, Mr. A. B. Matthews of Kansas City signed the following agreement which explains itself.

KANSAS CITY, MO., Dec. 14, 1889.

To Paul Paquin, State Veterinarian, Columbia, Mo.

I hereby certify that I desire you to inoculate against Texas fever, 64 head of cattle to be shipped south this fall (December); and I do so knowing that vaccination of the kind is *still an experiment*, and that the length of time during which inoculated cattle may resist Texas fever is unknown, and knowing also that the standard strength of virus for such inoculation has not been thoroughly established and protection may vary in consequence. I agree to have the stock next spring where it can be reached on information furnished by myself should re-inoculation or medicinal treatment be deemed advis-

able. I also agree to give you fully the history and location of the cattle from the time of this shipment until the middle of the summer of 1890 at least, so that the results may be utilized as part of the experiments that you are making on Texas fever.

SIGNED: A. B. MATTHEWS.

Mr. Matthews was in haste to ship his cattle south and desired and demanded by letter and verbally a *rapid* and *strong* inoculation. At his suggestion, as it was in line with our experiments, Mr. Paul Evans, my assistant, inoculated, Dec. 16th, 21st, 23rd, 65 head of black cattle with very *severe doses* of *strong virus,* the results of which have proven a valuable lesson. The stock in consequence contracted a *too strong type* of Texas fever and those that *survived* were shipped *while suffering* from the malady. Many *never* fully recovered their equilibrium, but on the contrary, influenced by the deadly germs on southern soil, they *continued sick* and became worse than they were before being exposed. It was in fact a continual, increasing illness from the moment of inoculation until death.

The following letter from Mr. Matthews explains itself concerning this inoculation. It was written before he had learned of the deaths.

KANSAS CITY, MO., Feb. 6th, 1890.

Mr. Paul Paquin, State Veterinarian, Columbia, Mo.

DEAR SIR: Your favor has remained unanswered on account of absence and business.

As explained to you in a former letter, *five* of the cattle which we inoculated at Little Blue, *died.* The *symptoms were that of Texas fever*, except that they were much worse in the right hind leg than I have ever seen animals with that disease. I attribute that difference to inoculating them on the right side of the tail, thereby affecting the right hind leg first. In this I may be mistaken. Otherwise the symptoms were *exactly* as I have seen cattle *die with Texas fever* and lost thousands of

dollars in a few days thereby. The cattle I shipped to Texas are all right at the present time, so far as heard from.

I am sorry to learn that you have no virus to inoculate more cattle. I had desired to inoculate a car load of pure bred and take them to Fort Worth and exhibit at the cattlemen's convention there, and thereby demonstrate to Texas cattlemen that blooded cattle can be inoculated and shipped south of the fever line with safety. But if you have not the proper virus, it is now too late to obtain the same.

I desire to say that inoculation against splenic or Texas fever is certainly practicable, and the man who accomplishes that great work is not only a benefactor to his State, but to the nation at large. I believe that you are on the right track, and think the *State of Missouri* should afford you *every facility* for carrying out and *perfecting* this work. I need not say that the *State of Texas should furnish you the cattle* to make the experiment, and that the State of Missouri should furnish you with funds to go to Texas and procure the cattle, and thereby interest the two States in this work, which will be a national benefit. Any thoughtful business man will understand this statement without argument.

With good wishes, believe me, yours very truly,

A. B. Matthews.

Shortly afterwards Mr. Matthews wrote that he had lost a large per cent. of his cattle. Later on Capt. Kennedy, in a Texas newspaper, gives his opinion against inoculation, judging solely from this *single* test, which was only an experiment in our legitimate line of researches after the truth, and which after all proved two things to the satisfaction of even some doubting stock-men: first, that Texas fever *is inoculable*; second, that if vaccination is to be successful it must *not be so severe* as to cause what may be called severe disease.

CATTLE SHIPPED TO MR. C. D. FOOTE, SAN ANGELO, TEXAS.

The following agreement was entered into with Mr. Foote:

COLUMBIA, MO., Dec. 19, 1889.

To Paul Paquin, State Veterinarian, Columbia, Mo.

I hereby certify that I desire to have inoculated against Texas fever 30 head of cattle shipped South on the 18th inst. (December), and I do so knowing that vaccination or inoculation of the kind is still an experiment, and that the length of time during which inoculated cattle may resist Texas fever is yet unknown; and knowing also that the standard strength of virus for such inoculation has not been thoroughly established and protection may vary in consequence or even fail. I agree to have stock during the next three months, and next spring, where it can be reached, on information furnished by myself, should reinoculation or medicinal treatment be deemed advisable. I also agree to give you fully the history and location of the cattle, from the time of this shipment until the middle of the summer of 1890 at least, so that the results may be utilized as part of the experiments that you are making on Texas fever; and I further bind myself to follow strictly the directions you have given me to care for the stock, etc., and should you or I ever deem it necessary for the protection of yourself and experiments, I agree to publish this contract in full in Texas newspapers and in any other paper where such proceedings may be useful.

SIGNED C. D. FOOTE,
San Angelo, Texas.

These cattle, all of which were thoroughbred Herefords of various ages, were inoculated in Texas, by virus furnished from our laboratory and under written instructions of the writer. Mr. Foote carried on the work admirably and with enthusiasm, and to him much is due for the grand achievement. From the weekly reports that he made we could well judge of the faithful work. I

give here extracts from these reports: "The cattle which I got from Mr. R. B. Price, of Columbia, and for which you so kindly prepared medicine seem to be doing all right and I report condition at this time, that you may make any suggestion before the time for turning them out.

The thirty cattle were shipped from Fayette on the 18th of December and arrived here on the 24th in the morning. They came in a Street stable car, without unloading and arrived in excellent shape, but tired. Before unloading they were inoculated as per your direction and then driven directly to the farm ten miles. Then they were all enclosed and kept on sorghum during inoculation period. Weather warm and sultry....."

Then Mr. Foote gives the temperature of each head of cattle which averages about 103 deg. F. and expresses his impression as follows: "I expected the temperature to run much higher than this." I will remark by the way that this is a valuable point. The cattle should not be inoculated to actual sickness but only mildly as just stated.

The results of this trial and the method of inoculation (that had been prescribed) I clip from a published letter of Mr. Foote.

KIOWA FARM, March 6, 1890.

Ed. San Angelo Standard.

DEAR SIR:—Agreeable to promise made some time ago, to give results of experiments in inoculating cattle against Texas fever, for publication, I have to say the results so far have been perfectly satisfactory..... After being inoculated (before unloading Dec. 24,) they were driven ten miles to the farm and the inoculation repeated every fourth day for sixteen days and their temperature taken with a fever thermometer. They were placed in a small yard on the south side of a shed, and before putting them in, all mangers and every thing else was removed and new feed troughs and mangers put in and shed whitewashed throughout.....Their temperature during the time they were kept up ran from 2 to 5 deg.

above normal, but other than this there was no evidence of fever. My instructions from Dr. P. were to put them after keeping them isolated for twenty days, in the worst infected pasture.....Not one of the thirty(all at grass) have shown any symptom of sickness. They are now in a better condition than when they came here.....

Mr. Foote then gives the following comparisons of cattle not inoculated brought into the same neighborhood. "About Dec. 1st R. R. Wade bought 22 heads, eleven are dead. P. C. Lee during the fall got three lots; out of one lot of six, five are dead and a large percentage of the other two lots. Comer Bros. bought thirty head in November—eleven are dead. M. H. Erskine, bought five in December two of which were sick but were saved. Thomas McCall of Concho County, bought ten head in December—six are dead. Malloy Cattle Co., of Concho county, are said to have lost more than two-thirds. I do not believe that there is a lot of unprotected (or unvaccinated) cattle in a radius of fifty miles that has not had the fever..... Why have not my cattle had it? Some if not all have taken just as good care and given as much attention as I have. It is possible and some tell me it is probable that with the warm weather my cattle will come down, but if every other one's cattle have had it in the winter why has it not come here? As to Dr. Paquin's theory I leave that for him to explain. This experimenting was his, made for him, and reports were regularly made to him.....If he is correct the discovery is worth millions to the West; if not correct, I am satisfied he will keep at it until he gets there.*

SIGNED: C. D. Foote.

From personal inquiries I found that the percentage of death of imported cattle not inoculated, in the neighbourhood of Mr. Foote was 57 per cent. this winter, whilst not

*Before going to press, a letter from Mr. Foote dated the middle of April says that all the cattle are still doing magnificently in spite of heat. P. P.

only did this gentleman save all his, but they were not ill and have been improving as before mentioned.

DEDUCTIONS FROM EXPERIMENTS OF ARTICLE III.

1st. That if Texas fever is, as has been written, of the obscure nature of malaria in man, it is nevertheless surely inoculable and is due to an appreciable germ.

2nd. That this germ or microbe, even when cultivated artificially, may be inoculated to cattle with dangerous effects.

3rd. That susceptible cattle, (i. e. of the North) may be purposely inoculated with virus of Texas fever, and thereby placed in the same relation with that disease, as are the cattle born south which become primarily inoculated from their mothers.

4th. That one single inoculation, mild or powerful, is not a sufficient protection against Texas fever, and that the virus must be of certain power and prepared purposely with the greatest care and by scientific methods.

5th. That inoculation with too strong virus, causing high fever, or positive serious signs of Texas fever, is not a sure protection, but instead is a dangerous practice and may kill stock directly, or cause such damage in the system that when exposed to the virus when thus suffering or soon thereafter, the subjects gradually get worse and die,—*never* having regained their strength.

5th. That periodical inoculations, beginning with a mild virus and ending with a stronger, is more rational as being more like the natural process of inoculation of southern calves, and is in a large degree a protection against Texas fever.

7th. That possibly the safest method of inoculation is to complete it on southern soil after shipment, providing that there be no exposure to the germs during the period of inoculation, particularly at the beginning.

8th. That the best results of inoculation thus far, are obtainable when the greatest care and attention is given to the inoculated stock before and after it is exposed.

ARTICLE IV.

THE GERM OF TEXAS FEVER.

A malady due to a germ is simply one produced by very small parasites; microscopic organisms termed germs, microbes, bacteria, etc., which grow in the body at the expense of the tissues, blood, etc., and thereby cause various kinds of disorders, such as fever, nervous phenomena and several other symptoms. Therefore the knowledge of the life of such germs is necessary to understand thoroughly the nature of the diseases that they cause respectively. However, the explanation of such biological questions is of more interest to science than to practical men; and as we are still investigating doubtful points concerning the life of the germ of Texas fever, and as we have much material of more immediate utility to the masses, I will write this time as briefly as the problem allows on this particular point, upon which it is my intention to publish special articles, practical and scientific, sometime in the future.

As explained in the beginning of this bulletin, we have purposely abstained during our work from consulting any writer on Texas fever. Before writing this, however, I have carefully and conscientiously gone over the reports of the investigators who have studied Texas fever before us, and have compared the results with ours, in which we have much valuable positive and negative evidence.*

In regard to the priority in the discovery of the germ I have this to say: It seems that almost every investigator who has used the microscope has seen it in one or more of the stages of its development, but none have fully realized its significance. Dr. H. J. Detmers and Dr. D. E. Salmon have, at the time, attached some importance to the forms that they respectively noticed,

*While preparing notes for this, Dr. F. Billings kindly forwarded to me, unsolicited, some slides made when he studied Texas fever. I can only mention this favor at this writing.

and Dr. Detmers has, I am informed, always had faith in his findings. He deserves credit for his tenacity to a just cause. The Bureau of Animal Industry however, seems to have abandoned whatever significance its officers have attached to the figure 8 germ, that they found in the bile, and which really is one of the appearances of the microbe in question, for not long since Dr. Theobald Smith of that section of the U. S. Department of Agriculture, published an interesting account of his latest researches, and claims that the disease is due to intra-globular forms not susceptible of cultivation, and that their effects are only on the red blood corpuscles which they destroy. He has not succeeded in inoculating the disease.

I myself have seen the germ of Texas fever in spleens as far back as 1883, but I did not then appreciate its value.

But Dr. Frank S. Billings has grasped and explained better than any the significance of at least one form of the germ. He has understood much that investigators before him misunderstood, and has foreseen largely the possibilities and properties of the parasite.

I do not in the least mean to be personal in saying, by the way, that there is reason for much criticism on the question at hand and the frequent discoveries (?) of germs. It is unfortunately true that many investigators formulate opinions wide in their scope and construct theories of public moment on very doubtful testimony. Carried by pardonable enthusiasm perhaps, or by the very human desire to be first, hasty conclusions have been given that will long blot the American history of medicine.

The glory, if glory there be, in the simple discovery of a germ, and proclaiming the wonderful thing to the world, is ephemeral, insignificant, and overshadowed by the brilliancy of the very truth that underlies one valuable, beneficial fact, established on a solid foundation by conscientious labors, no matter how slow and how long these labors may have been; but when that germ turns out to be a doubtful thing the would be discoverer has moreover injured the people, his profession, and himself.

In matters as obscure, as misleading, as difficult as are many problems in bacteriology, no one is warranted in making assertions of moment after only a few observations or a few experiments.

We do not pretend to be on impregnable grounds as to details; but we have worked much, and have sufficient data to speak, and if after all we find ourselves in error, we shall correct the mistake, as we have already assured our readers.

I appreciate fully the great efforts of all the investigators in Texas fever. I am animated only by a sense of duty and justice, and am not making disparaging reflections. Speaking in the name of truth and science, I consider no one's personality, and sink my own.

Judging from researches necessarily limited by time and circumstances, Dr. Billings concluded from his observations of the germs in tissues and culture, that in the mature form, their longitudinal diameter is about twice that of their transverse, that they are very small, ovoid, and have rounded extremities with special affinity for stain. (Pages 75 and 76 of Bulletin of Agricultural Experiment Station of Nebraska. Nos. 7, 8, 9, 10, June 1889.)

It is true one finds the ovoid (and cocoid?) forms both in the animal organisms and in cultures, but after investigating during two years a very large amount of animal tissues and fluids of various kinds, and after studying a great number of cultures, I believe that conclusion doubtful. The *small* ovoid, seems only a period during the vegetation of the organism before complete maturity. From present indications I think the mature form is different and much larger, and perhaps the organism completes its life outside of the body. But I will let my readers judge for themselves.

In analyzing the liver and spleen of infectious southern cattle we may find two or three forms, i. e. forms more or less ovoid which predominate and may be

scattered, but are mostly grouped in masses in the *intimity** of the tissues and corpuscles; a few short rods around which may occasionally be seen an areola (a light shade), and long large rod forms, sparsely distributed here and there. If cultures are made from such material the ovoid forms elongate, become surround by a gelatinous capsule or areola, and break off into at least two short rods, or double and single bodies mostly ovoid in appearance, and they may be seen within a capsule. By special processes of staining it is possible to obtain the capsule and all in same body. It is also possible to get all these forms on one slide and have them all at once under the microscope; observe Fig. 1. . There, may be seen the single and double (cocoid and) ovoid bodies, elongating forms, large rods, some showing the surrounding capsule, etc. This illustration is exact, and is from an absolutely pure and inoculable culture made from the bile of an infectious Arkansas cow,—bile with which we afterwards produced Texas fever. It shows at a glance and better than I could describe, the various forms which this germ assumes during its growth, and made apparent by staining. And now, if you will study all the figures, you will perhaps form an idea as to the adult form. In the figure from a photograph of bile with the bacteria that it contained, will be seen forms which *perhaps* represent the truly adult stage as in the outerworld. It is comparatively easy to get all the shapes and appearances that I have mentioned. To observe them all, one only has to study very carefully, by safe and sure bacterial methods and *for months*, the vegetation of the germs in different culture media and under various conditions, whether the origin was from southern cattle of infectious grounds, or from northern stock suffering from Texas fever, or from any reliable source. Perhaps he will be confused for a time in finding so many shapes and sizes, but presently he will get

*This word intimity is perhaps not used in the English language, but it has a correspondent in French, and means about this: mingled closely within. P. P.

into the right groove and will be able to trace the origin of every one, especially if drop cultures, and drops of blood (under proper care) of infected stock, are patiently and long watched. The long or large germs found in fresh organs disappear gradually, and the smaller ones only are found in preserved specimens, especially those kept in alcohol.

If one immerses in pure glycerine a fresh piece of liver of infectious southern cattle, or of any northern animal with the fever, in a month or more there may be seen on its surfaces fine white specks that gradually develope until they are roundish bodies as large as the head of a pin or larger. A section through the tissue will reveal the same condition of things within the organ. These granules (and neighbouring substances) contain crystals, and living inoculable germs of various appearances, but they are seemingly those of Texas fever.

A way to find several forms of the germ, is to fill a sterilized pipette of bile from the gall bladder of an infected southern animal, or better, a northern with the fever, seal it and let it stand for some weeks or months; gradually whitish granules and flakes will be deposited as in the liver and forms as in Figs. 1 and 2 may be noticed. Occasionally many appear stained brown, perhaps by the coloring matter of the bile. (Chemical analysis of these deposits are now under way by Prof. Schweitzer.) This color and the crystals mostly disappear in contact with acids. These substances are decidedly more prolific and pronounced in bile from an acute case of fever.

It may be objected that there was some "*post-mortem history*" connected with our germs, our cultures, the liver, bile and other specimens from which we form opinions. The fact is we have taken the greatest possible care to meet this convenient objection, and we have had, generally speaking, the same results from infectious southern cattle *killed* in Texas, in the Indian Territory, in Arkansas, those brought here and *killed* purposely; from natives with the fever *killed* purposely, or immediately after death

had occurred, and from inoculated cattle, pigs, and other animals.

Identical cultures were obtained from *infectious* animals of the south, and *diseased cases* in the north, in the field and at the laboratory. As to those granules, as will be seen further, we have succeeded in inoculating them to cattle, and other animals, and produced seemingly the forms of Texas fever germs.*

We have not had the above results with liver and bile of northern cattle *not* suffering from Texas fever, or exposed to its virus.

As hinted, perhaps the parasite passes only a phase of its life within the animal body, and completes it outside, as was suggested by Dr. Theobald Smith of the Bureau of Animal Industry, in the article already referred to and entitled, "Preliminary observations of the micro-organism of Texas fever," contributed to the Medical News, Philadelphia, Dec. 21st, 1889.

In the kidneys, lymphatic glands, blood and urine, the germs are usually in some small forms. As Dr. Smith states, the red blood corpuscles become affected. In cases of fever in northern stock small forms adhere to the blood corpuscles, penetrate into them, and cause them to appear crenelated, irregular in shape, lumpy, knotty from the parasitic bodies within; perforated, distorted in fact. They seem to perish so rapidly, that in a few hours or in a few days at most, the blood has lost much of its solid elements, becomes more watery, and hemoglobin passes into the urine.§ But it is incomparably less severe in southern stock. In their blood we find the same germs in lesser number, and the blood corpuscles are in part more or less diseased too, but they resist, as is evidenced by the apparently good health of the subjects; however their livers and certain other organs, are full of the parasites. The

*I do not yet consider these inoculations positive evidence, however. P. P.

§The urine becomes bloody in appearance.

tissues and blood of an infectious southern animal, are much like the tissues and blood of a case produced by inoculation of *most of ordinary cultures*, or other mild virus.

Dr. Smith in the article quoted formulates the following definition of Texas fever. "It is essentially a blood disease. There is a continous or paroxysmal destruction of red-blood corpuscles due to an intra-globular parasite, and the disease results mainly from the incapacity of the internal organs, primarily the liver, secondarily the spleen and kidneys, to transform and remove the waste products resulting from such destruction....."

From our work, I could scarcely admit such an exclusive definition. The germs being present outside of blood corpuscles, in the liver, spleen, lymph glands, kidneys *as well as* in the blood of southern infectious cattle and diseased northern stock, and growing more or less in all of those organs and fluids, indicate a modification of this conception. Since around, on, and in the blood corpuscles, as Dr. Smith has well said, are found almost only cocoid and ovoid bodies, single or in pairs, in greater or lesser numbers, is not this phenomenon, an attempt on the part of nature to destroy the parasites at this phase of their life, through the action of the blood corpuscles, rather than a docile submission on the part of the corpuscles to the voracity of the germs? I am inclined to consider the ravages of the germs more extensive. Indeed the traces of these are plain in other parts than the blood, even in infectious southern stock. In a sudden invasion of cattle unprotected by the immunity contracted south, or by artificial inoculation, the parasites develope with wonderful rapidity in many organs, which become impaired, and thus the nourishment on which the blood depends for rejuvenation, becomes improper before the germs have overcome the blood corpuscles. The microbes seem to win the fight, because other parts of the body had been previously weakened. We made some experiments to solve this problem. 1*st* we produced Texas fever by *feeding* virus; 2*nd*, by inoculation *subcutaneously*; and 3*rd*, by *intravenous*

inoculation In the first cases the germs appeared in the blood in sufficient quantity to master it only at a late hour, —after the liver and spleen, etc., had been invaded and much impaired in their phisiological functions. In the second cases the germs appeared in the blood in a few hours, in large quantities, but most of them disappeared shortly, and four or five days later only a few germs and a few diseased corpuscles could be found; on killing the subjects however, they were found plentiful in the liver and other organs. In the third cases, in giving a moderate dose the animals became violently ill, and could scarcely rise; the blood had more germs than corpuscles; many of these perished, but eventually the germs became scarcer and scarcer, the distorted corpuscles also disappeared, and yet the subjects, when killed after they had sufficiently recovered to regain their feet and eat, their livers and some other organs still harbored millions.

As Billings, I have found the germs motile but only in certain forms. In drop cultures, as well as in infected fluids or pulp from diseased subjects purposely killed, I have found this to be the case. They roll on themselves, change place under the microscope, advance, bend to and fro, try and shake themselves loose from their capsules, etc, etc.

The large forms in old bile sometimes show a slight waving motion. The spherical, ovoid forms and short rods, are often in zooglea, both in fluids and in the liver. When such zooglea are in drop cultures there may be a kind of slow bending, slow shaking motion on the part of some of the organisms to free themselves from the mass. The same thing is noticable in cases of new cells trying to free themselves from the surrounding gelatinous matter of mother cells. A flagellum has been noticed at the extremities of some germs highly magnified. That appendage is perhaps the motor apparatus.

Before closing this article I sincerely ask my readers to kindly examine all the illustrations in the bulletin and

read their explanations. They have much significance concerning the nature of this micro-organism.

As stated, we are still engaged in studies to sift the biology of the forms mentioned in connection with our investigations. Next year we hope to write in a more positive and more scientific line.

DEDUCTIONS FROM ARTICLE IV.

1st. That the germ of Texas fever is susceptible to many changes during its vegetation.

2nd. That the spherical, ovoid, and other forms, which several authors have seen, represent so many different periods in the life cycle of the parasite, or were different appearances due to different staining including or excluding the envelope, and none of them seperately could be sufficient to prove the identity, and form a complete history establishing positively the discovery of the true nature of this micro-organism.

3rd. That in the more mature stage the germs vary in size; some having measured 4 and 5μ in length, and 1.7μ in width; and that in the transitory ovoid stage, the dimensions may vary from 2.5μ in length, by 1.5μ in width, to 3μ by 1.5μ.

4th. That probably the microbe passes only part of its existence in the animal body, and completes it in the outer world.

5th. That its modes of reproduction, the nature of its growth, and its various forms studied in tissues, fluids and cultures, indicate an organism of the baccillar class, though possibly, the adult stage in the outer world, is akin to the form named cladothrix.

ARTICLE V.

ARTIFICIAL CULTIVATION OF THE GERM OF TEXAS FEVER.

It is not my purpose to enter here into any scientific explanation, that could not benefit those for whom this bulletin is written. I hope to give more details later with the biology of the microbe.

For the benefit of those unacqainted in the premises, I will say that artificial cultivation of germs, means simply a process by which they may be reproduced at will in vases, test tubes, or dishes, just as seeds may be sown and plants reproduced and grown at will in a hot house, at any time and during any season, even though the place of cultivation be foreign to the natural habitation of the plant. The disease germs are generally considered little plants, and artificial cultivation is one mode to grow them. When an animal or man is ill from any malady due to germs, it means that the germs in question are growing in that individual at the expense of the tissues, blood, etc. In cultivating disease germs, one substitutes an artificial nourishing media for the animal body or other natural food.

No part of our work has offered more and greater difficulties than the artificial culture of the germ of Texas fever. Beef broth peptonized, solidified with agar-agar or gelatine, or in a liquid state; blood serum, egg albumen, (Tarchinoff's), amniotic water, artificial lymph, liver broth, potato, and several other media have been tried. We have found that they develop best in a mixture of artificial lymph that I prepared, with liver broth which Mr. Evans succeeded in keeping in a semi-solid and transparent state.

Pure cultures can be obtained from the liver, spleen, kidneys, etc., of *southern cattle* of the *infectious districts*, or from their *calves before* or *after birth*. There need be *no post-mortem history about them*. Simply go south, kill the subjects, and with the greatest care possible inoculate your cultures by proper and safe bacterial methods, or take the germs from such organs, of a northern animal suffering from the fever. Or if you prefer, you may find them but *less virulent* in the urine and fœces.

Pure cultures can also be obtained from the blood of such cases, but more rarely, and with greater difficulty. At some periods the germs seem to have little activity in the blood, and a particle of blood on a needle, thrust into a gelatinous mass, does not always cause a growth. How-

ever, we have succeeded in getting pure and inoculable cultures, by making an incision in the jugular vein, or carotid artery, inserting the point of a specially contrived test tube, breaking it inside of the vessel and allowing a drop or more to run into the tube and mix with the semi-fluid culture media. Cultures from blood have developed the *same forms* as the germs found in the liver and other organs, or found present in cultures therefrom.

ARTICLE VI.

TRANSMISSION OF TEXAS FEVER.

As may have been gleaned from the preceding pages, there are many sources of contamination in this disease. Waters, soils, manures from the south, urine, bile, liver, spleen, kidneys, etc., of infectious southern stock have been mentioned as being capable of conveying the fever. That is not all, we have found the parasites also in *ticks bloated with blood of infectious southern cattle.* So this must be added to the list of sources. But from all these origins, there seems only one principal mode of infection in the natural condition of life, that is *by ingestion.* I mean that the cattle swallow the germs and thus get the disease. It may be possible that germs deposited in dusty roads, or mixed with the dust raised by the winds be inhaled, breathed by susceptible stock, and the malady thus induced, but such is certainly not the usual way.

These facts will satisfy at least in part, the many opinions on the question at hand, and perhaps will help to clear the obscurity prevailing in all minds, and which I presume caused Dr. Theobald Smith to write as follows in his article already quoted: "As to the external character of the disease we have *still to learn how* southern cattle carry the disease-germs while they themselves are immune; how the germs multiply on the pasture and *how* they enter the susceptible organisms of the northern

cattle, and *whether or not they are* eliminated from the diseased body to become a *fresh center of infection.*"*

At this writing, I would not venture to give details as to the actual vegetation of the germs on the grounds, although I might be pardoned an opinion based on many laboratory cultures and some observations of other kinds. But as we are engaged in researches in that line I leave the point for another time. Sufficient it is to say, that germs excreted from of the body of southern stock, are *not at once* capable of much damage, but must first vegetate, thereby becoming virulent, whilst the virus from tissues for instance is more readily inoculable. Virus excreted by diseased northern cattle is still weaker than from the southerners, and becomes virulent outside after a longer time.

Texas fever is transmissable not only from southern stock to susceptible northern cattle, but under favorable circumstances, is inoculable *between northern natives*, although in the ordinary course of things in our climate transmission does not occur. We have inoculated native Missouri cattle with spleen and liver pulp from *other diseased natives* and produced typical cases of Texas fever, but it took large doses of virus. The rapidity of the course of the malady depends much on the origin and age of the virus. It was more rapid from old pulp kept in warmth and properly preserved than it was from virus of fresh matter, and it seems impossible to cause severe *Texas* fever with *fresh* urine, whilst the same exposed to warmth awhile becomes dangerous.

We have succeeded also, though with great difficulty, to induce the disease in sheep, guinea pigs, white mice, white rats, and very rarely rabbits, kittens, and swine. The germs may be reproduced by inoculation of liver and spleen pulp in any of these subjects, but the quantity must be large and the gross typical spleen lesions are not always to be found.

*The italics are mine. Our experiments furnish answers to the Doctor's remarks, in part at least. P. P.

Indeed the *typical* spleen enlargement and softening, and the bloody urine in a case of Texas fever produced by inoculation are not always present, *nor* are they *always* present in ordinary accidental cases in cattle. It depends largely on the virulence of the matter inoculated, the atmospheric temperature, the susceptibility of the subject; and the virulence depends on the generation of, and the influences on the germs outside, after their passage through one animal body, and before their reception by another individual.

The very act of cattle eating fresh germs that have *just* been deposited on the ground by a Texas cow for instance, is not necessarily followed by perceptible fever. We have tested this and found that both on the grounds and in artificial cultures, the first generation (or generations perhaps) coming from virus just excreted from the animal body are not dangerous. It seems that the parasite has a *resting* period after being thrown out during which its virulence is very mild; and then the extreme virulence will come after several weeks, if the germs receive sufficient warmth and moisture. We have seen in this writing, that native Missouri cattle exposed with Southern stock immediately on their arrival here, in a pen of a few square feet, where they must swallow the parasites while eating, did not show fever before about a month, and in cases where those pens were shaded it took longer still. In those cases the germs were brought here by southern cattle and had to recuperate on our soil; it is the same thing when the disease is brought accidentally anywhere. Now in cattle exposed in *Arkansas* and *Texas*, where the germs are *always* on the grounds, and consequently are already virulent, the animals die within an average of *twelve days* from date of landing, during the warm seasons. Reports from Drs. Dinwiddie, of Arkansas, and Francis, of Texas, show that our unprotected stock exposed there died within ten to fifteen days. Thus it takes once or twice as long for our native northern stock to die of the fever when the germs are brought to *our* pastures by

southern cattle and dropped with manure and urine, as it takes when exposed to them on the *southern soil itself,* where the parasites receive almost constant warmth and sufficient moisture, and are therefore, always virulent. Germs artificially cultivated give results on the same principle.

Investigators who have pursued researches concerning Texas fever, seem to have expected, by inoculation, always the typical lesions of the malady, as usually found when it originates by accident and runs an acute severe course. This is surely an unreasonable demand. One must allow for degrees in this disease as in any other. As stated above, the softness of the spleen and the bloody urine are not always present in accidental or purposely induced cases. It is simply the same malady with a lesser or greater degree of lesions. This is not the place to discuss this pathological question however, I merely desire to draw the attention of the readers to the fact that in producing Texas fever by inoculation, if only mild lesions are produced, providing that they are the same in character as are those of a typical case, that they are produced by the same germ, that the same germs are found in both, that the cultivated germs of both cases are alike in forms and mode of vegetation, that inoculations practiced with germs of animals rendered ill by inoculation cause again the growth of similar germs and the advent of lesions of identical character, the proof is *sufficient.* In inoculating Texas fever one must always remember the peculiarities of its virus, its many forms, weak one day, stronger later on, etc.

The following tabulation of part of our inoculations speaks for itself. It is selected because of the variety of the virus used and the many sources.

All the inoculations not otherwise specified were hypodermatic and mostly in the tail.

INOCULATIONS OF OTHER ANIMALS THAN CATTLE.

Date of Inoculation.	Animals Inoculated.	Kind of Virus Used and Record Marks.	Results.	Microscopic and Post-Mortem Appearances and Remarks.
1889.				
July 10...	Gopher.....	Liver of Ark. steer.....	Seriously ill: staggers.....	Germs developed locally, then generalized, and subject recovered.
July 10...	Black Guinea pig.	" " "	Died Aug. 12.....	Germs of Texas fever found in blood, liver, spleen, etc.....
July 11...	Yellow Guinea pig	Cult. A3 of Texas cattle urine	" " "	Germs similar as found in preceding cases and in same organs, etc.
Aug. 2...	White Guinea pig.	Piv. spleen native cattle	Apparently ill.....	Recovered ....
Aug. 15..	Black Guinea pig.	Culture U3.....	Died —— ——	Post-mortem, unfortunately, missed until too late.....
Aug 16 to Sep't. 3	Thirteen different Rabbits	Different fresh and old cultures.....	Some slightly ill; none seriously.....	Occasionally corpuscles of the blood found diseased; somewhat crenelated.....
Sep't. 4..	Rabbit in cage 11..	Large dose cult. BO3	Died Sept. 7th.....	Found germs of Texas fever in liver, spleen and blood.....
Sep't. 5..	Guinea pig " 2..	Culture D2.	Slightly ill.....	" " " " " " blood. .....
Sep't. 9..	6 mos. ordinary pig (swine).....	Liver of native with Texas fever	Died Sept. 13	Lesions in liver and blood as those of Texas fever; same germs; they produced good cultures. See figures..... .....
Oct. 1....	Black kitten.....	Cult. 9¼ from native cow.....	Died Oct. 2.....	Germs found in blood, liver, etc., as those of Texas fever
Oct. 11...	2 small white mice	Cult. CF4	Died Oct. 13.....	Liver enlarged; blood, liver and spleen had Texas fever germs....
Oct. 18...	2 white mice.....	Cult. D" '	Exceedingly sick; one killed Oct. 19, other died Oct. 20	Germs and lesions similar to those of Texas fever; spleen not enlarged but gorged slightly .....
Oct. 18...	2 white mice.....	Cult. D13.....	One died Oct. 19.....	Same lesions and germs as in preceding case.....
Dec. 28...	3 whith rats.....	Cults. ABM', X" A., 9¼ A ...	All slightly ill.....	Germs found in their blood as in Texas fever.....
Feb. 13...	2 sheep	PA2 and PA3 in thigh.....	Decided lameness and illness.	Germs found in their blood as in Texas fever.....
Feb. 13...	2 white rats.....	" " In tail...	One died Feb. 15..	Both have germs of Texas fever. .....

In all the inoculations mentioned above, it was possible to identify the germs satisfactorily, and then make from various specimens, cultures that became virulent and produced *in cattle* the same germs, the congestion of the liver, the distorted blood corpuscles, etc., as occur in Texas fever.

Inoculation of any other animal than cattle has been found difficult. were made in the course of our experiments. Still the following tabula- variety for our purpose.

INOCULATIONS OF CATTLE

Date of Inoculation.	Animals Inoculated.	Kind of Virus and Record Marks.	Av. fever with in 5 days.	Results.
1889.				
June 29	Red steer	Vaccine from urine of Texan	103°, F.	Sent to Arkansas; lived
" 29	Red heifer,	Vac. from manure of Texan	103 1-5	" " "
July 6	Red hornless heifer	Germs from ticks	102 3-5	Contracted fever in Ark.
" 20	Small red heifer	Vac. from spleen of native.	103 2-5	Exposed to fever and lived
" 20	Spayed heifer	" " " "	103	" " " "
" 26	Roan heifer	Culture I4	103¼	" " " "
" 26	Red heifer,	Culture L3	103 3-5	" " " "
" 26	Red heifer	Vac. from liver of Ark. cow	103	" " " "
Aug. 9	Heifer	Strong virus from liver Tex'n	104 1-5	Died on car
" 15	Long-horned cow	Fed potato culture U6	106	Died Aug. 22
" 16	Small spotted heifer	Intravelnous inoculation U6		Died Aug. 16.
" 16	Heifer, right horn broken	Native liver and spleen pulp.	105 3-5	Died Aug. 24.
Sept. 5	Big-jaw steer	Culture BT3	103	Sick; killed Sept. 20
" 5	Old cow	Culture U6'	103 1-5	Recovered.
Oct. 3	Cow No. 5	Culture 9½ in vein	104	Exceedingly ill; recover'd
" 16,19,23	Forty-one bulls	Mild and strong vaccine	104	Some stagger'd; 40 expos'd Indian Ter'y; 39 lived
Dec. 28	Heifer	Vaccine virus weak ABM	103	Slightly ill
" 31	Calf, four months	Culture XY'A	102 1-5	Very slightly ill.
" 16,21,23	Sixty-five head cattle	Very strong vac., large doses.	105	All ill; 5 deaths
" 24	Thirty head Herefords	Graduated vaccine	103	Sent to Texas and lived
1890.				
Jan. 17	Red roan heifer.	Cult. AM' veinous inoculat'n.	102 3-5	Very sick
" 17	Little red steer	Cult. AM'	103	Exceedingly sick; killed
" 17	Old cow.	Cult. AM' in vein	103 1-5	" " staggers
Feb. 13	Heifer	Old manure moistened, etc	103 1-5	Weakly.
" 13	Stall No. 3 heifer	Cult. P. A'	103	Ill and weak
" 13	Stall No. 4 steer	Cult FA3 from ticks	103 1-5	Weakly.
" 13	Steer	Granules from liver of South'r	102 4-5	Slightly ill
Mar. 20	Cow..	Granules from bile of native	102 4-5	Indisposed

It always took large doses. Many fruitless, and few successful attempts
tion does not give all that we have on record, but shows a sufficient

AT LABORATORY, ETC.

	Microscopic Revelations, Post-Mortem Appearances and Remarks.
Lesions of Texas fever. Had previously in blood, germs produced by inoculation from the ticks	
Germs found in the blood taken from the ear. Corpuscles mildly but typically impaired	
Found the germs in drops of blood; corpuscles distorted	
Mr. Hampton pronounced it Texas fever. It was produced by inoculation	
Typical case Texas fever; soft spleen, bloody urine and the germs	
In a few hours the blood was mastered by the germs. SAME CULTURE that caused preceding death	
Typical case of Texas fever. The germs present	
Mild lesions of Texas fever. The germs present	
The blood presented the germs and the corpuscles were typically diseased	
Blood full of Texas fever germs for several days—gradually disappeared	
{Cattle of J. J. McAlester. See page 27	
{Germs in the blood as inoculated and the blood mildly modified, as in Texas fever	
Germs in blood and corpuscles impaired, as in Texas fever	
Germs present in blood, which is clearly though mildly affected	
Characteristic cases of Texas fever. See A. B. Matthews' letter, page 29	
Cattle of Mr. C. D. Foote. See his letter to San Angelo Standard, page 32	
Typical germs and lesions of Texas fever in blood	
Germs of Texas fever in blood, bile, liver, etc.; lesions in tissues mild, but characteristic	
Germs found in blood, which is much affected, typically	
The blood and corpuscles show the germs of Texas fever	
Killed within three days, and germs of Texas fever found. Typically distributed in liver, spleen, blood.	
Blood analyzed and found to contain the germs, as inoculated. Corpuscles distorted	
Texas fever germs found in blood	
Corpuscles distorted, etc. Germs in blood and affecting the corpuscules	

DEDUCTIONS FROM ARTICLE VI.

1st. That susceptible cattle contract the disease generally by swallowing the germs thrown out with urine, manure, etc., and that the breath does not cause it.

2nd. That the germs after passing through the animal body are not ready to cause disease, but take some time to become deadly,—consequently the germs spread in the usual way on northern grounds, must first recuperate virulence, *unless* they were brought from the south in *old manure and old urine* adhering to the feet.

3rd. That ticks full of blood from infectious southern cattle, may, it seems, scatter the germs on our lands, though ticks *of themselves cannot* convey the disease.

4th. That the disease is inoculable from native to native, and would be transmitted between them if our warm seasons were extended enough, and if our frosts were lighter.

5th. That the malady is inoculable in a mild form to other animals than cattle, such as sheep, pigs, guinea pigs, white rats, white mice, etc.

6th. That in all animals inoculated the germs of Texas fever, and the most truly characteristic lesions that they cause, are reproduced in a more or less pronounced form.

ARTICLE VII.

THE PRINCIPLE OF IMMUNITY—HOW TEXAS CATTLE CARRY THE GERMS OF TEXAS FEVER AND YET REMAIN APPARENTLY HEALTHY. VACCINATION.

There are many theories advanced concerning the principle underlying immunity conferred by inoculation, vaccination, or an attack of disease. Smallpox is prevented by one attack, or by vaccination with cow pox*

*Some renowned authorities claim that cow pox and horse pox are identical.

during the existence of which the system is rendered proof against smallpox for a *certain period;* charbon is prevented *for a certain period* by one attack accidentally contracted, or purposely inoculated in a mild form; black leg is prevented just the same way, and so are several other affections of a specific character. Texas fever we found to be preventable on the same line.

As mentioned, immunity, however, exists in any disease only for a time. Smallpox for several years, black leg for several years, charbon for a few months, Texas fever for a few months, etc., etc. In our experiments we found, as my readers have learned, that the Texas fever germs are always living in the bodies of the infectious southern cattle, and yet these remain apparently healthy. Thus, whilst the germs grow in them they are proof against an acute attack of the disease. But if infectious southern cattle are kept *north,* say in Missouri, for about a year, and then exposed to Texas fever again, they will contract the disease and may die. So they have immunity, or in other words, are proof against the disease, only for a short period, a few months or a year at most. This has been verified by actual shipments near Sturgeon, Mo., three years ago and by others throughout the state.

The fact that southern cattle which are proof against the disease, have nevertheless, the germs of it constantly growing in their systems, shatters a few theories of a general character, attempting to explain by what phenomen the body actually becomes vested with power to resist disease. In Texas fever, as perhaps, in several infectious diseases, it seems only a *question of tolerance.* The body becomes accustomed to the action of the germs and its products just as one becomes accustomed to take morphine, or to the climatic influences of fever and ague.

Now, as to how southern cattle bring us disease, whilst they seem free, it is very simple. They have been naturally inoculated or vaccinated from their mother's womb before birth, and then have been subject to the influence of the germs all their lives. Thus they can just as

safely carry the germs on them, in their bowels, etc., as a man, having had smallpox, or having been vaccinated, may carry the germs of smallpox on his person in any way, shape or form. Indeed he might swallow them with impunity to himself, and yet might distribute the virus and cause small pox in others.

Now concerning the transmission between natives, that rests solely on two conditions: the nature of the germs and the nature of the climate. It has been seen that the germs on southern soil, where it is always warm more or less, are always deadly except during cold times, and that cattle exposed there die within ten or twelve days. The same germs gathered on southern soil and brought here in a glass jar, say, have the same effects. But if southern cattle bring us the germs in *their bodies*, i. e., in their bowels and urine, the condition is changed. In such cases the germs deposited on our grounds remain harmless between one and two months at least. During that time, exposed to sun heat, and sufficient moisture, the virulence is regained, and *then* exposed susceptible cattle sicken and die. Now when our natives get the fever they deposit the germs on the ground just as the southern stock, but before the germs can gain virulence, the cold and frosty season of the north *is on them*, and modifies and even destoys their activity.

Some experiments, not given in detail in this bulletin show, as all observations do, that *cool weather* retards the *growth* of the germs, that *freezing point* for *several hours* intercepts the *regetation* to adult forms, and *long frosts* modify these even to destruction. The reason, therefore, that in the ordinary course of things, native cattle suffering from Texas fever do not transmit the disease to others, is simply because the duration of our warm season is not long enough to allow the germs to grow in virulence, after passing through the animal body. By inoculation and cultivation of germs from such stock we found this to be the truth, and those of my readers who have had the patience to read this carefully, have perhaps already come to this conclusion themselves.

CONCLUSIONS.

The conclusions that we have arrived at from the facts developed by *all our experiments* and researches are given here in direct reply to each proposition that we formulated when we began our work, i. e., the propositions that will be found on pages 6 and 7 of this bulletin.

1st. The Texas fever germs may be found in some surface soils, grasses and pond waters of the infectious districts of the southern states.

2nd. The virus is found in the liver, spleen, lymph glands, kidneys, blood, bile, urine and fœces (fresh droppings of manure) and is transferred to the north chiefly by the urine and manure.

3rd. Ticks and the feet of cattle are capable of carrying the germs to distant lands.

4th. The period of *incubation*, i, e., the lapse of time *between* the *moment* that germs are taken in the *body* by susceptible cattle and the *appearance* of the disease, is between eight and twelve days only. Cattle may be *exposed longer* and not become affected, but this depends on the weakness of the germs in conditions demonstrated by our field tests and inoculations.

5th. So far, experiments indicate that about 30 *days after leaving the southern infectious soil*, the southern cattle are not dangerous; consequently, if they were kept that long in quarantine north of the fever line, they could then be safely scattered among northern stock. More experiments are necessary on this point.

6th. The cheapest mode that we know now to disinfect cars and yards, is by quicklime, corrosive sublimate solution, or steam; but here again we mean to experiment

further. Chloride of lime has little value except to impart a pleasanter odor.

7th. The means to disinfect southern cattle alive, and render them harmless before shipping north is not settled and we shall experiment with that end in view this year.

8th. Inoculation was at first very unsuccessful, but afterwards proved beneficial. Properly inoculated cattle were shipped and exposed south with *little or no* damage. More experiments are needed on this point.

9th. Other animals than cattle, may, under certain conditions, when shipped by rapid transit, bring Texas fever north, and one good observation indicates that a shipment of horses has done so in the state of Missouri.

10th. During favorable weather, virus spread in the north with fresh manure and urine directly from southern cattle, becomes virulent in about 30 days, (and perhaps occasionally less) during the warm months, and remains virulent until decidedly cool weather.

11th. Under the circumstances explained in this bulletin, northern cattle suffering from Texas fever may communicate the disease to other northern natives, though this cannot occur in the ordinary course of things in Missouri,or any where north, because cold weather arrives too soon to allow the vegetation of the germ to virulent maturity.

12th. Calves born south become inoculated or receive the germs of Texas fever directly from their mothers before birth, and then continue to resist the germs, first because of this *natural* inoculation, and second, because of receiving the virus gradually, perhaps in the milk, and then when they begin to eat or nibble on grass.

PRACTICAL THINGS.

So far our work points to two things at least that may prove of practical value to the people. First, the means of preventing Texas fever by inoculation, thereby opening to all the northern states a grand market for improved cattle.

In spite of disease, a few people South risk and lose thousands and thousands of dollars yearly in their attempts to import that class of stock which may improve their herds; if we can prevent Texas fever our farmers and stockmen may make *hundreds* of sales instead of only a few sales annually.

The process of inoculation is simple and one may apply the virus in a few minutes (for each operation.)

The method of producing the vaccine or protective virus is not easily understood and none can procure a safe and active material, but he who has been taught and is a microscopist. In a nut shell however, the Texas fever vaccine consists of the germs artificially prepared or cultivated, weakened by heat or frost, and graduated and dosed according to age and size of the cattle to be inoculated. We are still at work to simplify and perfect the system. Then we can speak more specifically and more at length on the point.

I had written in detail the methods to make the vaccine virus, but on receipt of inquiries leading me to think that some incompetent person intended to try its production without sufficient knowledge and training, I concluded, at the last moment, to wait until this year's work is finished. If an incompetent individual should attempt such a thing, and fail, as may naturally be expected

of him, the whole proposition will be at once considered as doubtful, and the people will lose the benefits in view. So I will clearly state the principles involved in the production of Texas fever vaccine, when the whole work is complete, and we have simplified the matter.

The second practical thing is the means of transporting southern cattle without scattering Texas fever along the line. By our methods of shipment, as may be ascertained in these pages, we have transported to Missouri, from Texas and Arkansas, three loads of infectious cattle, and their droppings in the car proved harmless even when tested purposely. But this, I am sure, can be improved. If we can secure the consent, and the financial aid necessary, I feel that more simple means of safe transportation of southern cattle can be devised, by the practice of which, our interstate cattle traffic will be much simplified, to the great relief of the people and transportation companies.

The ultimate result of all this, we hope, will be the modification of the injurious quarantine lines and regulations, now existing between the south and north concerning Texas fever, and then a free and beneficial market that will enrich both sides equally.

If our funds were not so limited, we could accomplish much to that end in a comparatively short time, but as it is we have to go exceedingly slow, beg our way partly, and even make personal sacrifices. We may, therefore, be forced to experiment a long while yet.

But we are much gratified to present to the people of the State of Missouri, who have supported these investigations to a considerable extent; to the legislative members since 1885, who supported the State Veterinary law and improved it much; to the Boards of Curators since I am State Veterinarian, who always encouraged the Veterinary Department and the teachings of Veterinary Science in the State University; to their Excellencies,

Governors Morehouse and Francis, who, in their turn, officially favored and cheerfully encouraged these investigations of Texas fever, we are gratified I say, to present many hitherto unknown facts, that will be of practical utility to our country. We shall continue our work, until we find the truth about the points still obscure or still enveloped in mystery.

Notwithstanding all our hopes and expectations, the people will please bear in mind that we are *experimenting* and have not worked more than one year. We may be disappointed in many things, but we have grounds for further researches.

Your humble servant,

PAUL PAQUIN, M. D., V. M.

State Veterinarion's Office;
Laboratory of Pathology,
Columbia, April, 1890.

THE GERM OF TEXAS FEVER. (Magnified 1,000 Diameters.)

Explanation of the Figures.

Fig. 1. The microbe of Texas fever at various stages of its development, from a shaken liver-broth culture pure, one day old, (that became inoculable). Origin from the blood of a native suffering from Texas fever.

Letters a, d, h, point to the SMALL OVOID STAGE described by Frank S. Billings as the adult form: the letters b, i, g, present ovoid forms elongating and spots within; the letters o, c, as well as the b pointing to a small circle to the left of the figure show the cocoid appearance or perhaps the same forms as the preceding standing on end, and thus presenting a view of the top of one extremity; m, fine new forms to develop in the ovoid represented by a, b, h; f, r, germs sufficiently developed to show by dots, what seems at this stage to be the ends of new ovoid forms within; p, still further development of a mother cell showing two fine ovoid bodies within, which are to be freed, and appear then as shown by letters m, and later a, b, etc., etc.; e, k, figure 8 germ.—an appearance probably identical with Dr. Salmon's bacteria of Texas fever.

Fig. 2. Forms in a photograph of old BILE of a cow killed when suffering from Texas fever. Some may be crystals(?) but I think most represent the adult forms in the outer world. Some forms in such bile, not shown in the cut, had a flagellum, or prolongation at each end.

Fig. 3. Germs from a culture in beef broth; very well developed; proved inoculable.

Fig. 4. Germs from liver of HEALTHY Arkansas steer killed purposely; proved inoculable; furnished the culture represented in Fig. 3.

Fig. 5. Germs from liver of heifer KILLED when SUFFERING from Texas fever; proved inoculable; the bile of this liver furnished the germs for the virulent culture represented in Fig. 9.

Fig. 6. Germs from a liver of native, suffering from Texas fever produced by INOCULATION of liver pulp of Texas cow.

Fig. 7. Germs in liver of hog that died after inoculation of fresh virus from spleen of Texas bovine.

Fig. 8. Surface germs from blood serum culture, twenty-four hours old.

Fig. 9. Germs from bile (read Fig. 5) cultivated ON POTATOE; caused Texas fever by feeding and by inoculation. See tables of inoculation.

NOTE.—We gratefully acknowledge the assistance of Dr. H. J. Detmers and Prof. C. L. Herrick, of Ohio, in photographing or drawing three or four of these figures from our slides.

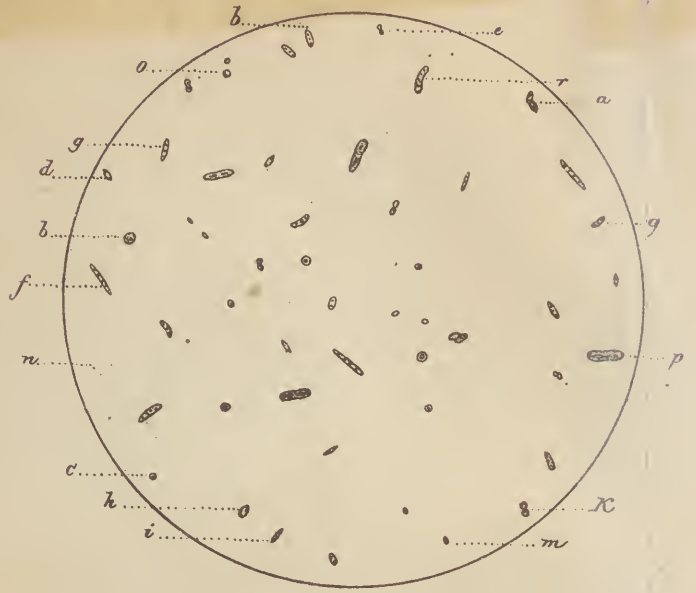
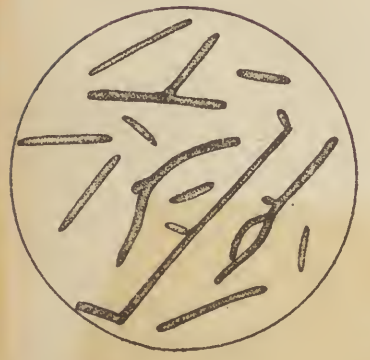


Fig.1. × 1000.



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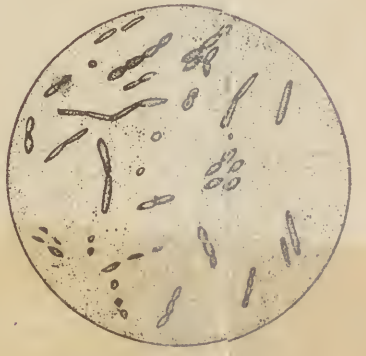

Fig.3. × 1000.

GERMS FOUND IN THE STUDY OF TEXAS FEVER.

Fig.4. × 1000.

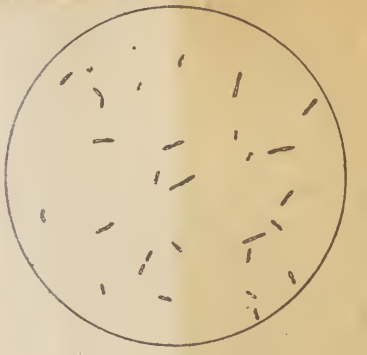

Fig.5 × 1000.

Fig.6. × 1000.

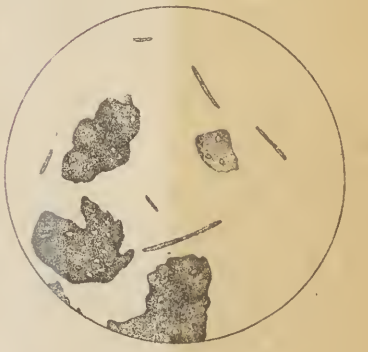

Fig.7. × 1000.

Fig.8. × 1000.

Fig.9. × 1000.